Armed Forces College of Medicine

AFCM

Reabsorption of Bicarbonate & Secretion of Hydrogen

by

Prof. Dr. Ibrahim Mohamady

INTENDED LEARNING OBJECTIVES (ILO)

By the end of this lecture the student will be able to:

1. Define sites of HCO_3 reabsorption

2-Describe mechanism of H secretion
3-Explain role of kidney in control of acid – base balance
4-Describe how the kidney can regenerate new HCO_3
5- Mention the important buffers in the tubular fluid

Introduction

- For each H^+ secreted, one bicarbonate is reabsorbed. Bicarbonate is reabsorbed mainly by the proximal tubule (85%), thick ascending loop of Henle (10%) and collecting duct (4.8%)

Site of Hydrogen Secretion

- H^+ is secreted in all parts of the renal tubule except the descending and ascending thin limbs of the loop of Henle.

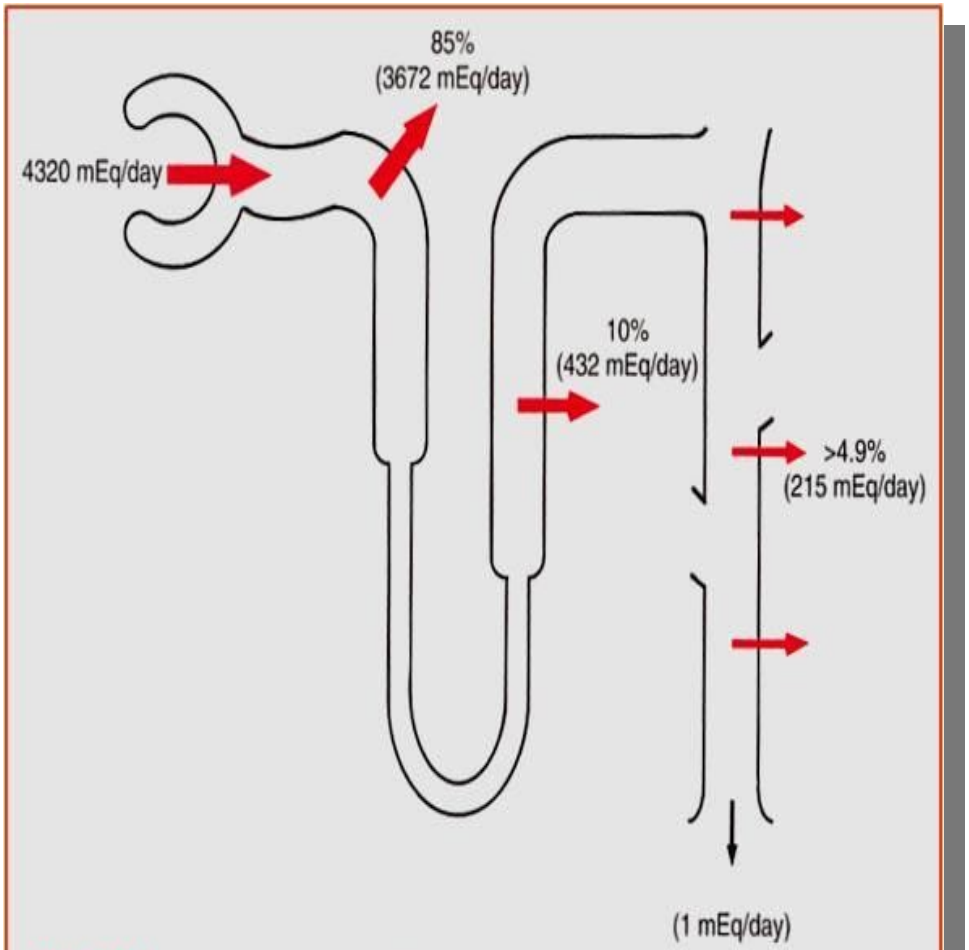


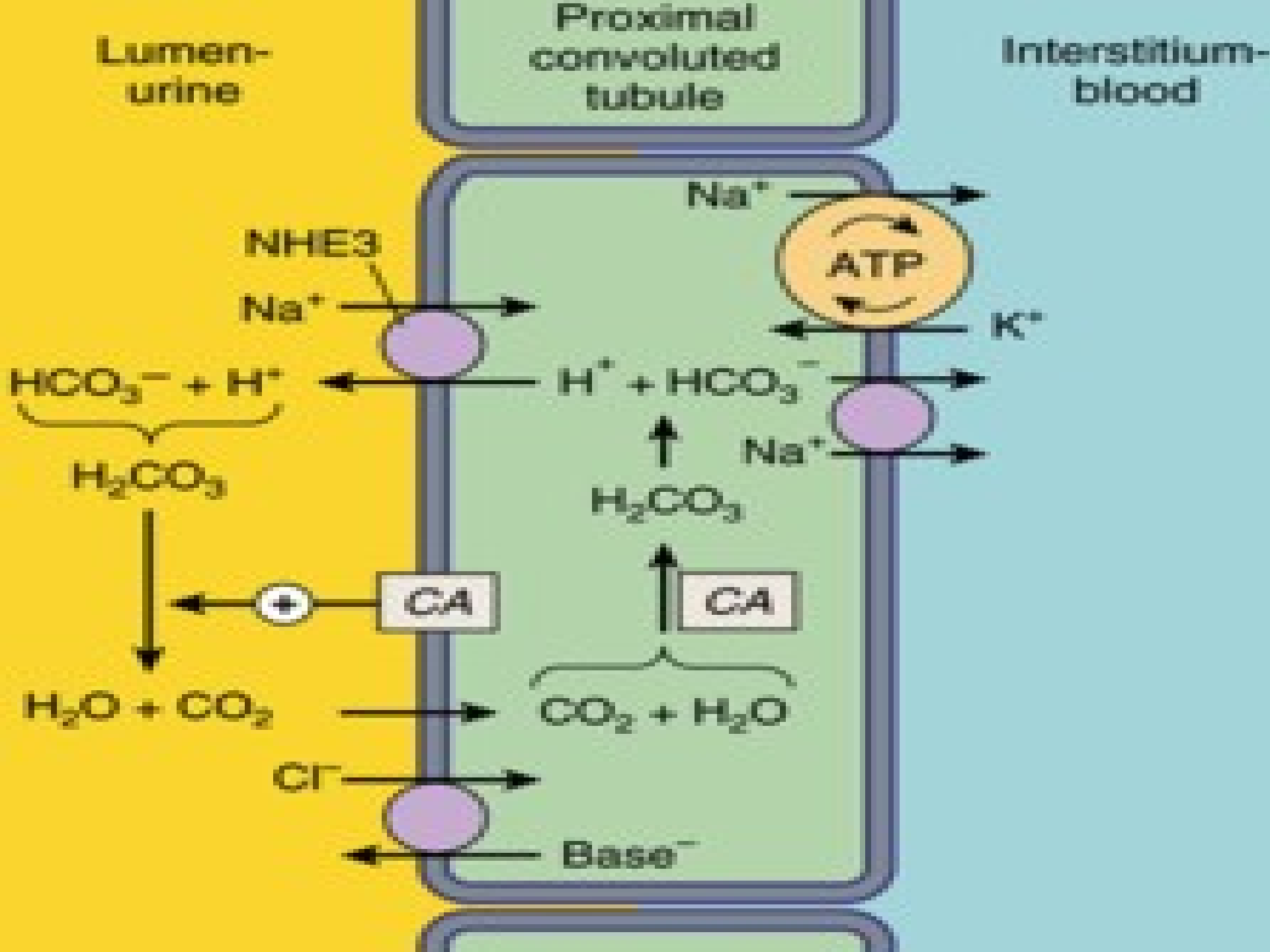
Figure 30–4. Reabsorption of bicarbonate in different segments of the renal tubule. The percentages of the filtered load of bicarbonate absorbed by the various tubular segments are shown as well as the number of milliequivalents reabsorbed per day under normal conditions.

Mechanism of H^+ secretion

1. Secondary active transport:

- Occurs in the proximal tubule, thick ascending limb of loop of Henle and initial part of distal tubule.

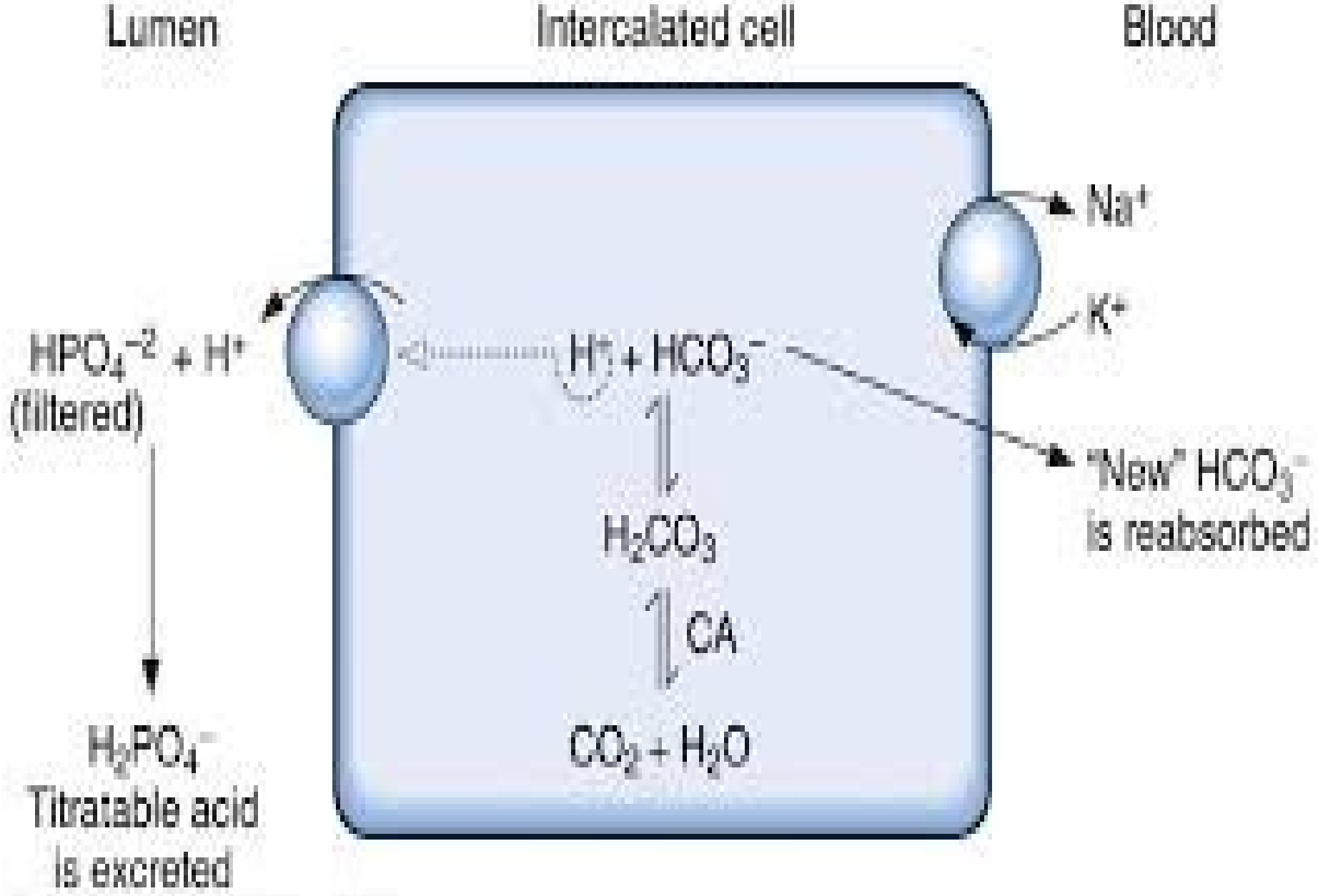
- The secondary active transport of H^+ occurs by counter-transport mechanism .


Lumen-
urine
Proximal
convoluted
tubule
Interstitium-
blood
Na+
NHE3
ATP
Na+
K+
HCO3− + H+
H+ + HCO3−
Na+
H2CO3
H2CO3
CA
CA
H2O + CO2
CO2 + H2O
Cl−
Base−

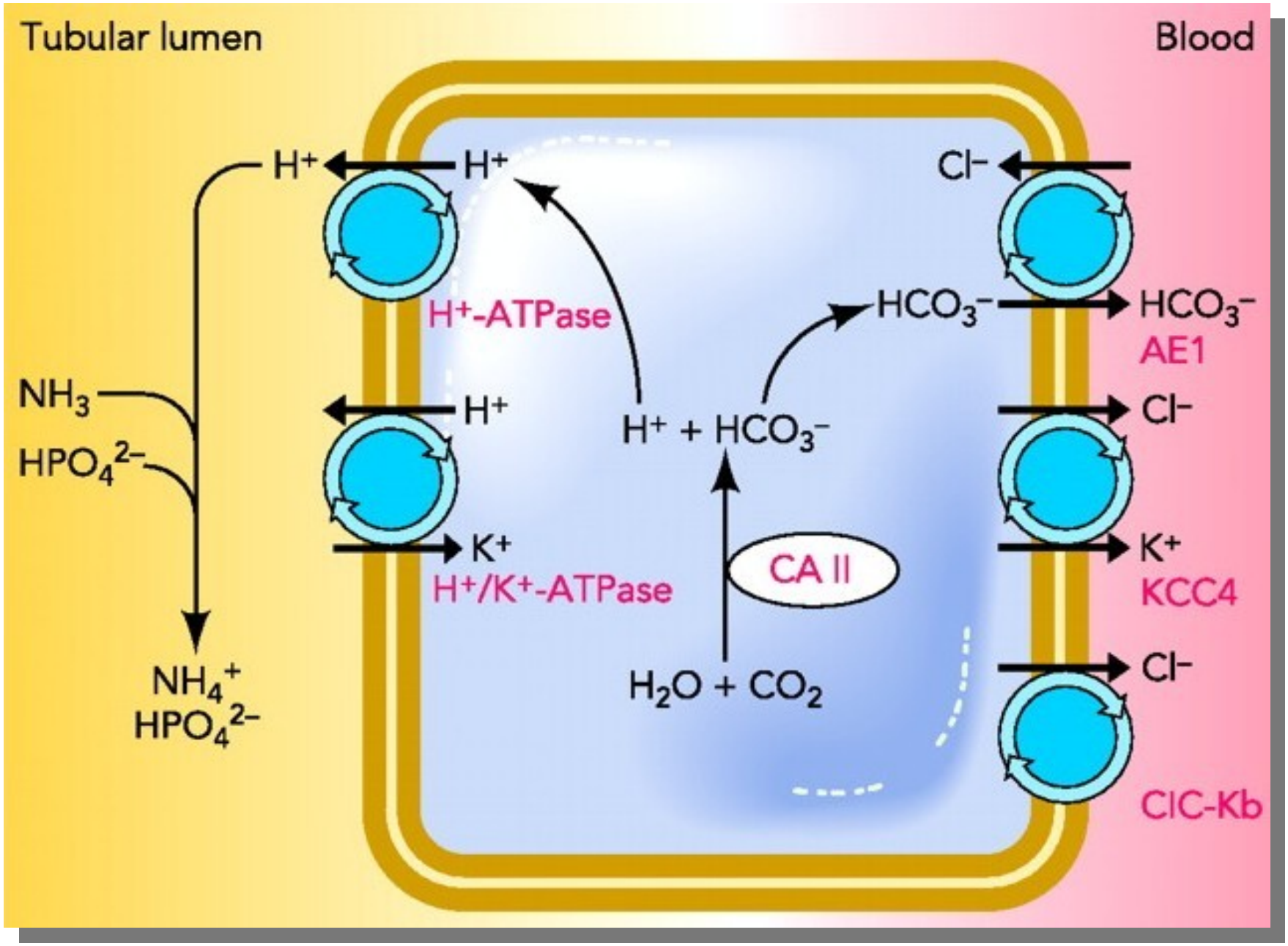
Mechanism of H^+ secretion

2. Primary active secretion:

- Occurs in the late distal tubule and collecting ducts by I- cells.
- It is Na^+ - independent.
- It is stimulated by aldosterone, which can be increased up to 900 folds.
- H^+ is transported actively by H^+-ATPase pump at the luminal membrane of the intercalated cells.



Copyright © 2007 Lippincott Williams & Wilkins.


Tubular lumen
Blood
H+
H+
H+-ATPase
Cl–
HCO3–
HCO3–
AE1
NH3
HPO4 2–
H+
H+ + HCO3–
Cl–
K+
H+/K+-ATPase
CA II
K+
KCC4
NH4+
HPO4 2–
H2O + CO2
Cl–
ClC-Kb

Fate of H^+ secreted

- The secreted H^+ is buffered by the buffers in the tubular fluid.

1-In the PCT:

- Buffering by the $NaHCO_3$ in the tubular fluid.The net effect is reabsorption of85% of filtered NaHCO3.

Fate of H^+ secreted

2. In the Distal tubule and collecting duct:

a) Buffering by phosphate buffer:

- 30 - 40 mEq of Na_2HP0_4.are available.
- H^+ is buffered as follows:
- $H^+ + Na_2HPO_4 \rightarrow NaH_2PO_4 + Na^+$
- NaH_2PO_4 is excreted accounting for most of the titratable acid.
- This process results in secretion of H+ and net reabsorption of newly synthesized HCO_3^-

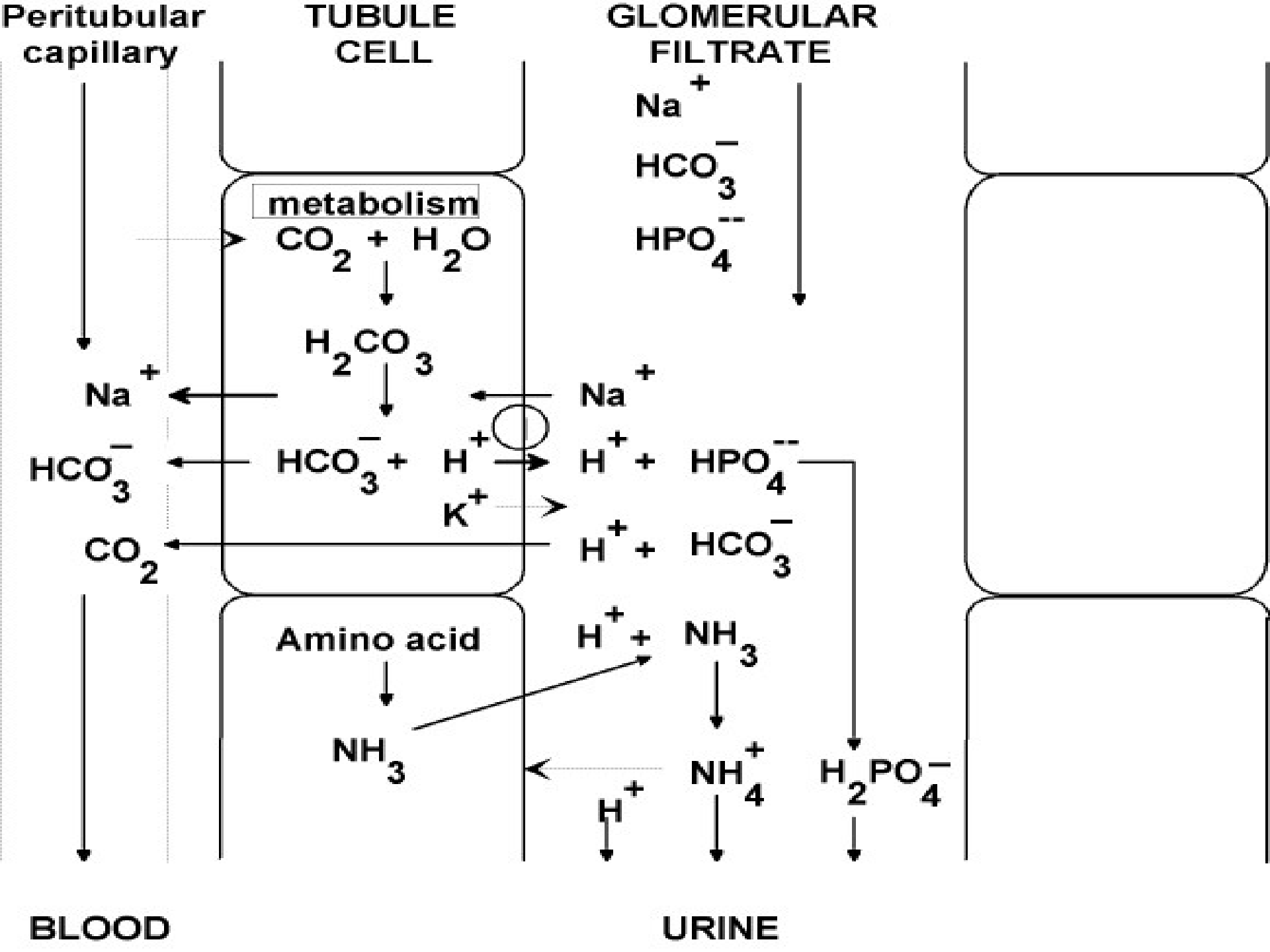
Fate of H^+ secreted

b) Buffering by ammonia (NH_3):

- NH_3 is formed in most parts of the renal tubule from glutamine.

Glutamine —(glutamunase)→ **glutamic acid + NH_3**

- NH_3 is lipid-soluble and diffuses into the tubular fluid. H^+ combines with NH_3 to form NH_4^+, which is then excreted in urine together with Cl^- (from NaCl) forming NH_4Cl. Na^+ are reabsorbed together with the HCO3 adding new NaHCO3 into blood .


Peritubular capillary
TUBULE CELL
GLOMERULAR FILTRATE
Na+
HCO3−
HPO4−−
metabolism
CO2 + H2O
H2CO3
Na+
HCO3−
CO2
HCO3− + H+
Na+
H+ + HPO4−−
K+
H+ + HCO3−
Amino acid
NH3
H+ + NH3
NH4+
H+
H2PO4−
BLOOD
URINE

Importance of H^+ buffering

H^+ secretion in the distal tubule and collecting ducts occurs as long as the pH of the fluid in these segments is above 4.5 which is the limiting pH for H^+ secretion. If the secreted H^+ is not buffered, this limiting pH would be reached rapidly leading to stoppage of further H^+ secretion.

Factors affecting acid secretion

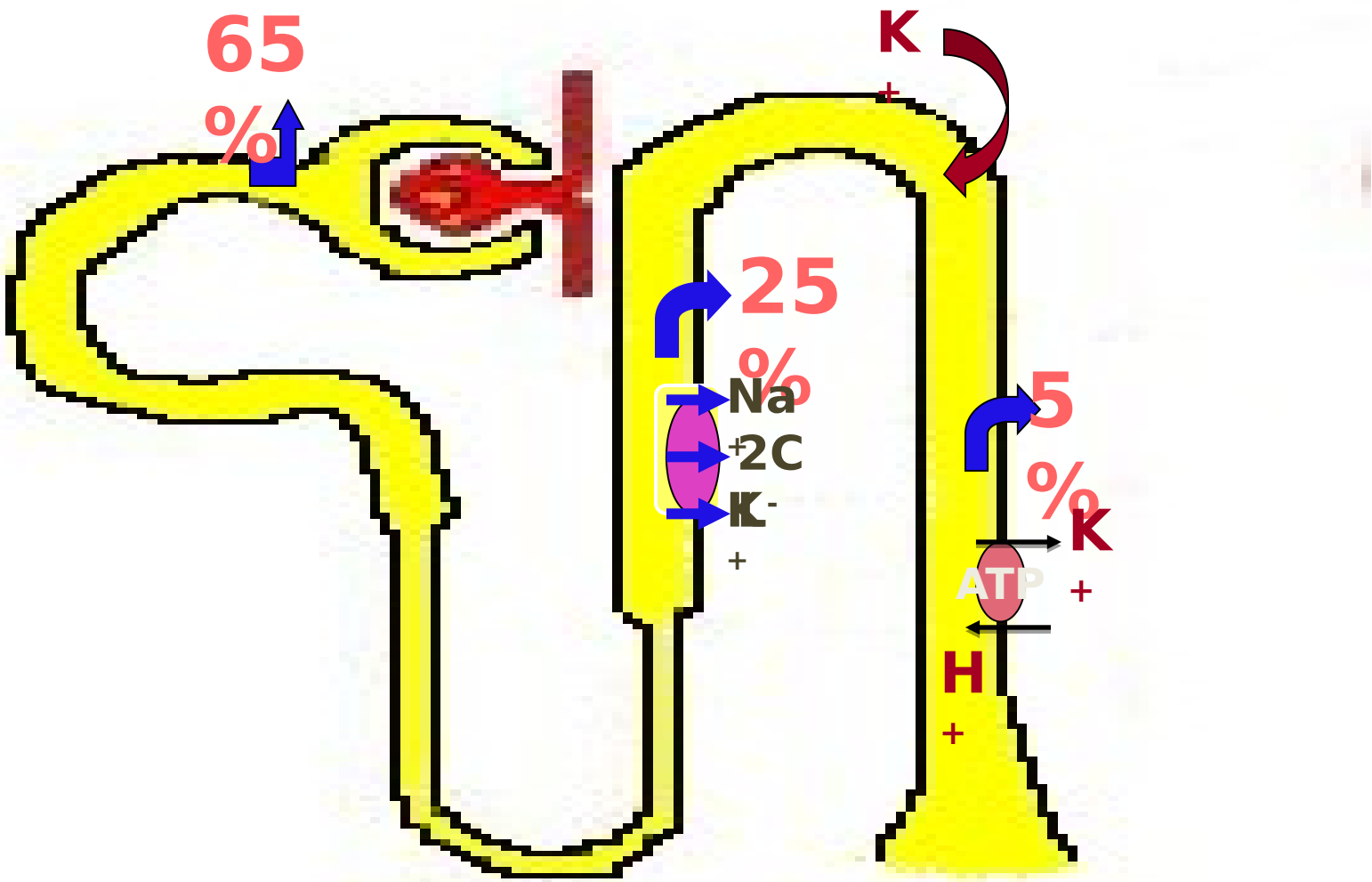
1) Aldosterone: increase H^+ and K^+ secretion.

2) lntracellular PCO_2: when PCO_2 is high (respiratory acidosis) more intracellular $H_2CO_3$is available and H^+ secretion is enhanced.

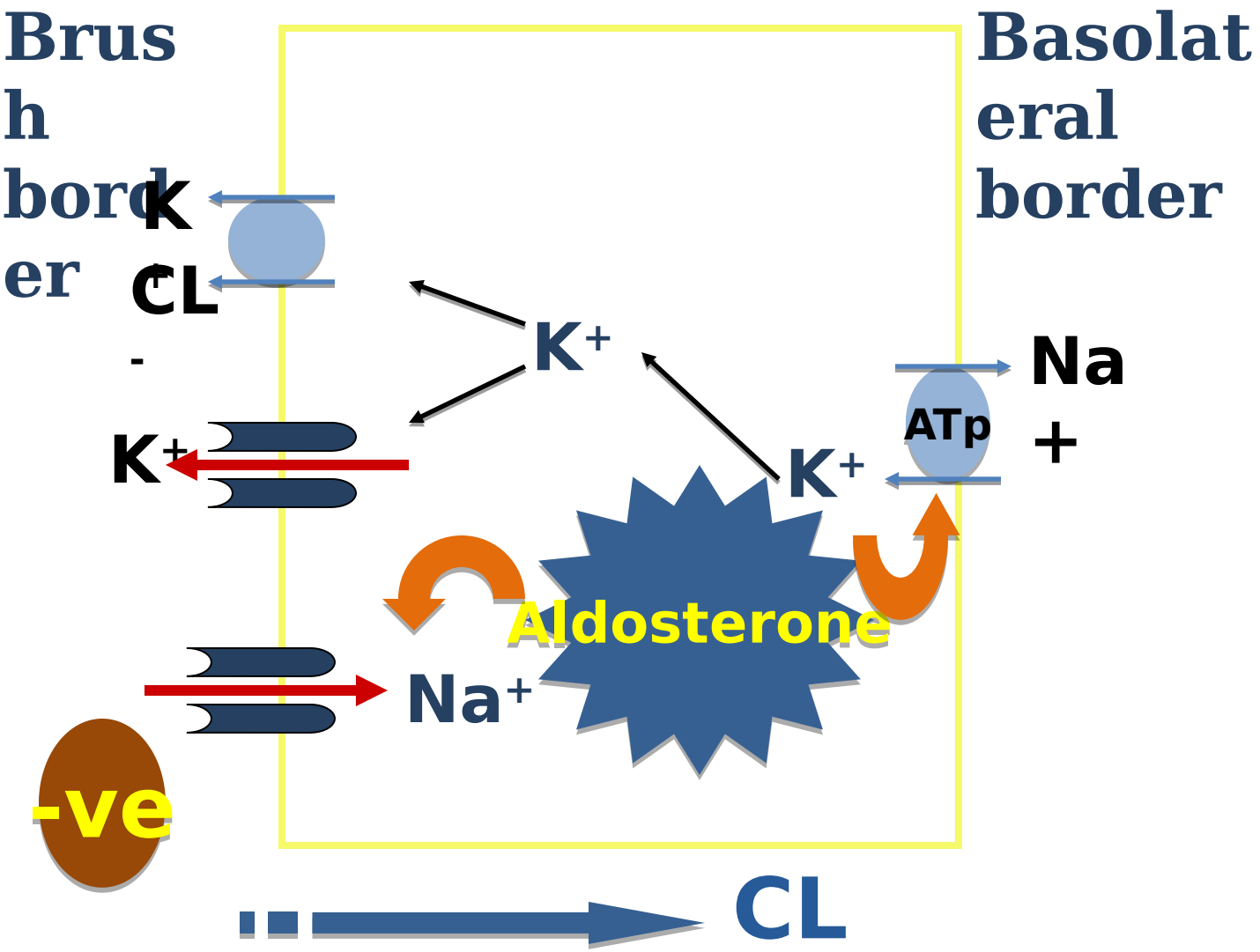
3) $K^{\pm}$ concentration in the cells:

a) K^+ depletion in the cells enhances H^+ secretion.

K+ reabsorption

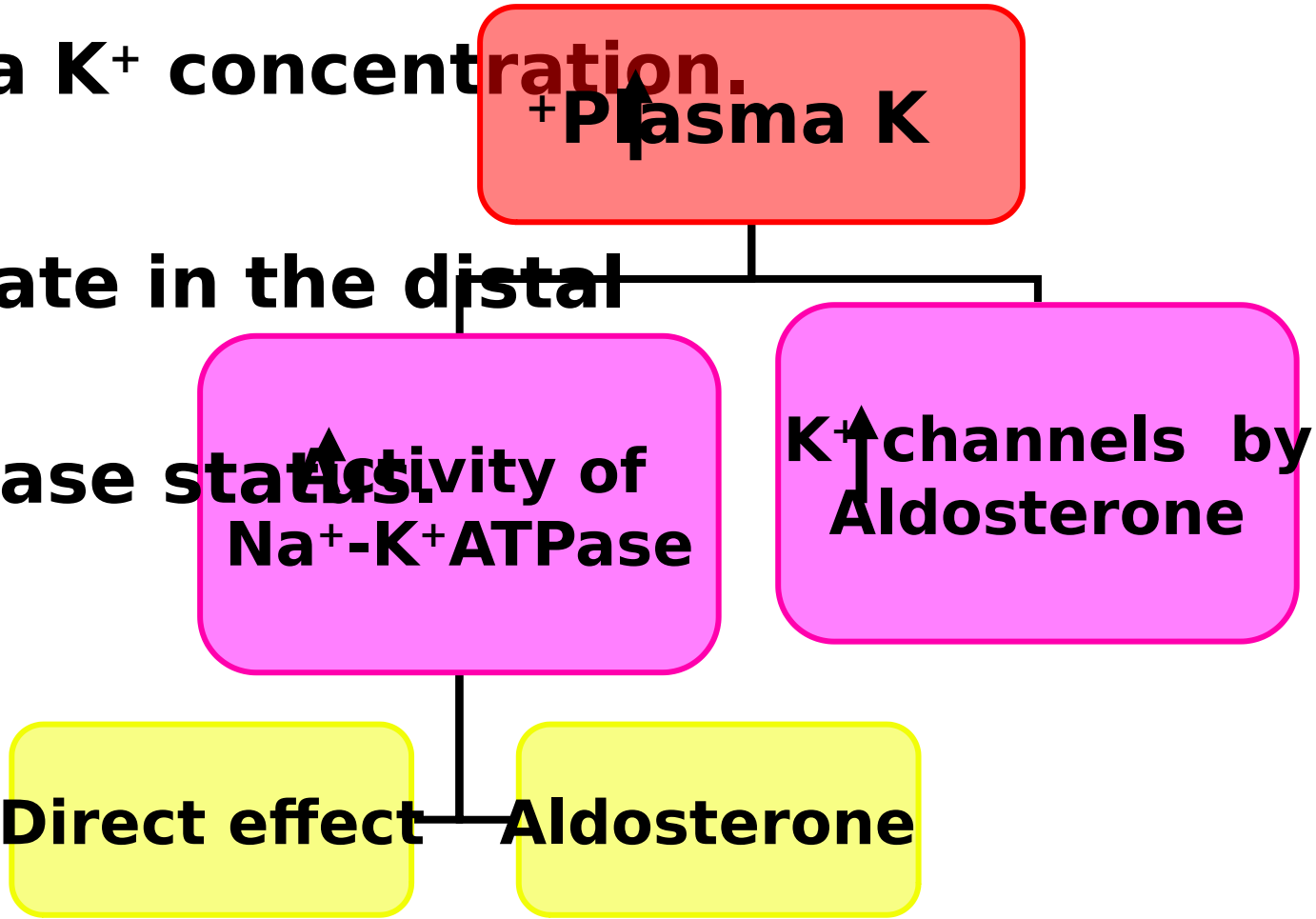


Potassium secretion by Late DCT & C.D



Regulation of K^+ Excretion

1. Plasma K^+ concentration.
2. Flow rate in the distal tubule.
3. Acid-base status.



Metabolic acidosis